IMPROVING DUCK MARSHES by WEED CONTROL

CIRCULAR 19—REVISED

FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR

IMPROVING DUCK MARSHES by WEED CONTROL

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FOREWORD

Killing the goose that laid the golden eggs has its modern counterpart. Today we are doing it a different way. As advancing civilization "reclaims" marshes and swamps throughout the country, habitat vital to the existence of wild ducks and geese is being destroyed.

During the past decade, efforts have been concentrated on accurate inventories of the continental waterfowl population. The time has come to put equal emphasis on habitat needed by the birds. Only by a coordinated, nationwide program of habitat management and improvement, including control of unwanted plants, can there be a continuing supply of waterfowl. And only thus can our waterfowl heritage persist as an important recreational resource for millions of Americans.

IMPROVING DUCK MARSHES by WEED CONTROL

Two factors explain why there is growing interest in the control of marsh weeds. One is the advent of new and better herbicides for the purpose. The other is the increasingly critical situation facing the nation's duck-hunting resource—on which 2½ million Americans spend over a hundred million dollars annually. Already more than half of the country's original 125 million acres of wetlands have been spoiled for waterfowl use. As national census figures continue climbing toward the predicted 200-million mark, more and more of the places where ducks feed, breed, and are hunted will have to be converted to the needs of advancing civilization. In other words, prospects are for fewer hunting places and lesser numbers of ducks for larger populations of hunters.

To help offset this trend, it is important to make the best use of what is left. Thousands of poor or fair areas in the United States can be made more useful for ducks and duck hunters by replacing marsh weeds with plants that furnish food or cover for waterfowl, Commonly, the costs involved are not prohibitive.

In Florida recently, 20,000 acres of waterhyacinths and other pest plants were cleared away from ponds and lakes by the Game and Fresh Water Fish Commission. Numerous other programs, both large and small, are being waged against phragmites, cattails, waterchestnut, and other marsh weeds in various States. On the Federal refuge system, more than 2,000 acres of marshlands are treated with herbicides annually to make them more productive for waterfowl. Yet all this is small compared with what can be done.

MARSH WEEDS DEFINED

Marsh plants are either assets or liabilities. Those that do not benefit waterfowl do the opposite by competing with desirable vegetation and lowering usefulness of the habitat. Growths that do not justify the space they occupy in terms of food or cover for waterfowl are regarded as weeds.

Species designated as weeds are not necessarily such in all places and times. Usefulness or lack of usefulness of a particular kind

of plant varies considerably, depending on local circumstances.[1] Bulrushes, though generally desirable, become so dense and dominant in some localities that they need to be reduced. In the South and some other regions, cattails compete too successfully with desirable plants in duck marshes, yet in the Northwest cattail marshes furnish useful nesting cover for redheads, ruddies, and other waterfowl. Similarly, though phragmites and needlerush have no food value for waterfowl they provide useful protective cover in some flooded feeding sites. In the latter type of situation, weed control can consist of opening up dense stands of the plants instead of trying to eliminate them.

Some weedy species are practically nationwide in distribution, whereas others have more restricted range. Cattails, phragmites, spatterdock, and willows are examples of wide-ranging marsh weeds. Waterchestnut is at present a problem only in the Northeast; saltcedar is confined mainly to the Southwest; and several troublesome plants such as alligatorweed, giant cutgrass, maidencane, needlerush, sawgrass, waterhyacinth, and waterlettuce are limited largely or entirely to the South.

The control of floating or floating-leaf plants such as waterhyacinth, waterlilies, and spatterdock is discussed in this circular, but submerged aquatics are excluded because their suppression is primarily the concern of fishpond management and a fishery leaflet[2] on the subject is available. Objectionable trees and shrubs of waterfowl habitat are discussed in the final chapter on Woody Weeds.

ACKNOWLEDGMENTS

Information in this booklet has been compiled from many sources. Much of it has come from studies or operations by the Branches of Wildlife Research and Wildlife Refuges of the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, cited in the text as FWS, and much has been drawn from tests conducted by State Federal Aid programs and by the Agricultural Research Service in its cooperative studies with the Bureau of Reclamation. Plant names, both common and scientific, have been based largely on Neil Hotchkiss's Checklist of Marsh and Aquatic Plants of the United States, FWS Wildlife Leaflet 210, 1950.

[1] Information on duck-food usefulness of various marsh and aquatic plants, as well as on their distribution, propagation, and environmental requirements, is given in Food of Game Ducks in the United States and Canada, by A. C. Martin and F. M. Uhler, Fish and Wildlife Service Research Report 30, 1951.

[2] Control of Aquatic Plants in Ponds and Lakes. Eugene W. Surber. FWS Fishery Leaflet 344, 1949.

GENERAL SUGGESTIONS

PREVENTIVE PLANNING

In creating new ponds, it is frequently possible to prevent serious weed-control problems by proper planning in the blueprint stage. An especially important step in this direction is the provision for draining and reflooding of pond basins. Such arrangements, as discussed in the section on Control By Water-Level Management, page 6, help avoid weed infestations or enable effective elimination of them. One of the advantages is the fact that pest plants can be plowed up or destroyed by other means while the pond is drained.

Another construction feature that helps minimize weed difficulties is the subdivision of large impoundments by means of dikes. This makes possible more efficient management of water supplies, both for weed control and for food production, especially when there is provision for independent flooding and drainage of each pool. Building the dikes wide enough to serve as roads permits ready access for inspections, weed control, and other operations.

PROMPT ACTION

In weed control, an ounce of prevention is generally worth tons of cure. Heading off serious infestations before they become well established prevents deterioration of habitat and costly control work later on. If the small colonies of waterchestnut found near Alexandria, Va., in the early twenties had been eliminated at that time, duck hunting, fishing, and other recreation on the Potomac River would not have been ruined for a couple of decades, and hundreds of thousands of dollars eventually spent on control of the plant could have been saved. The principle of timely prevention holds true for almost any marsh or pond. Destroying scattered patches of invading weeds before they have a chance to spread and become firmly established is the most efficient way of controlling weeds. There are two important prerequisites, however: Ability to recognize the objectionable plants, and periodic or seasonal inspections to spot early stages of infestation.

SELECTING THE BEST METHOD

Local conditions must help decide which is the best method for use on a particular weed problem. The kind of plant or plants, extent of infestation, depth and controllability of water, accessibility, and similar factors, need to be weighed against costs and merits of the various methods that can be used.

If local water supplies and water-control structures are sufficiently adaptable, adjustment of water levels often controls weeds and results in an abundance of desirable plants. Disking, mowing, or crushing provide satisfactory control of many weeds in marshes that can support mechanical equipment. Pulling by hand, mowing with a sickle, or spot treatment with herbicides are often practical for elimination of small patches of weeds. Combinations of methods sometimes prove particularly effective. These include mowing followed by flooding, burning and spraying, spraying and flooding, or use of two different chemicals. More detailed comments on various control procedures are given in the chapter on Methods (page 6).

BEST SEASON FOR TREATMENT

Most marsh plants have a particular growth stage during which control measures are likely to be especially effective—the vulnerable stage. Frequently, though not always, the ideal time for treatment is associated with the plant's flowering or fruiting, probably because of depleted food reserves. Needlerush appears most susceptible in the spring during its flowering. Mowing of cattails at two particular stages of growth yields a 95% to 100% kill, whereas numerous mowings at various times may result in little or no real control (see page 22).

In some plants, the ideal time for treatment shows no clear relation to the flowering or fruiting stages. Woody plants commonly respond best when control measures are applied in later summer or fall; giant cutgrass is killed most readily about two months after its flowering, during the period of maximum runner growth. Much remains to be learned about the ideal time for treatment of different species by different methods, and as more information is obtained on these matters control programs will improve in efficiency and economy.

REPLACEMENT BY USEFUL PLANTS

The success or failure of control measures depends not only on the extent to which weeds are eliminated but also on the kind, quality, quantity, and duration of the new plants that come in their place. Where useful plants are already present in a suppressed state, removal of weed competition is frequently all that is necessary to ensure satisfactory improvement. Thus, in a Maryland locality dominated by cattails, control by mowing resulted in good volunteer growths of wild millet, wildrice, and rice cutgrass for about a decade. However, satisfactory replacement cannot always be left to nature. Sometimes, seeding or planting is necessary soon after control operations to assure a good crop of useful plants and prevent rapid reestablishment of weeds.

METHODS

CONTROL BY WATER-LEVEL MANAGEMENT

Suppressing weeds by water-level management has been practiced in many places because of its practical advantages in economy and simplicity. The method requires sufficient water supply and a suitable type of dam to maintain desired levels at different seasons.

Various kinds of marsh weeds can be eliminated by drowning, either as seedlings or in more mature stages of growth. Flowering beds of lotus have been killed by a 30- to 36-inch increase in depth lasting for 12 days. Mowed needlerush was destroyed by an 8-inch rise in water level held for 3 weeks. Mowed cattails can be controlled more effectively when water covers the cut bases. Most tree and brush stumps lose their ability to sprout if covered by water during one growing season. Many other species that are somewhat tolerant of flooding can be drowned if depth and duration are sufficient.

An especially important water-level measure for improving vegetation is the seasonal drawdown. In certain instances, however, the drawdown can be a liability rather than an asset since more weeds or worse weeds can become established while water levels are down. Potentialities of the drawdown for good or harm depend upon local conditions—particularly upon plants, soils, and weather of the area.

In places where dark-stained water, excessive acidity, turbidity, troublesome weeds, carp, or similar factors limit production of good duck foods, it is often advantageous to drain or partially drain the pond basin during summer and raise wild or cultivated seed-producing annuals. Gradual restoration of water levels in the fall makes abundant food supplies readily available for ducks and geese. If weedy perennials survive inundation through winter and spring and become a nuisance, it may be advisable to omit the drawdown in some years so the undesirable plants can be drowned during continuous high water.

At the Patuxent Refuge, a system of alternating drawdowns on two adjacent ponds, one pond being lowered one year and the other the next, has worked particularly well. The plan has not only pre-

vented serious weed problems but has also provided good nesting conditions adjacent to excellent food supplies. In the Southeast, where control of one kind of weed sometimes simply clears the way for a worse one, wild millet, browntop millet, corn, soybeans, and other useful species are commonly planted in dewatered marsh areas that have been cleared of weeds and prepared for seeding by farm machinery.

Timing of water-level adjustments is especially important in drawdowns involving production of native (noncultivated) plants. The more rapid growth of desirable annuals, as compared with most perennial weed seedlings, frequently makes it possible to destroy unwanted plants and spare the good ones. At the Thousand-Acre Marsh in Delaware, thousands of seedlings of phragmites, hibiscus, swamp dock, pickerelweed, and arrow-arum have been drowned while permitting survival of young plants of wild millet, smartweeds, rice cutgrass, and fall panicum. If the timing of water-level change is wrong, however, more harm than good is likely to result. Excessive duration of a drawdown risks establishment of perennial-weed seedlings and serious spread of runner-producing plants such as phragmites and giant cutgrass.

Temporary drainage has been found advantageous for control of some weedy marsh and aquatic growths. Draining of beds of alligatorweed or waterprimrose allows more thorough spraying and better kill of the plants. Draining also facilitates mechanical control and enables the burning of old dead stalks of phragmites or needlerush prior to spraying. In some places, winter drainage followed by freezing of the marsh floor has helped get rid of undesirable plants. Flooding, following cutting or herbicidal control, is frequently helpful in eliminating plants such as needlerush, hibiscus, and buttonbush.

HERBICIDAL CONTROL

The use of herbicides in marsh management has increased rapidly during the past decade, and it will probably continue to grow as new and better chemicals become available. Several valuable new herbicides released within the past few years have given fresh impetus to work in this field.

DANGERS

Spraying marsh weeds with herbicides usually poses no direct danger to man, livestock, fish, or wildlife. In this regard, plant-control agents are much safer than other pesticides such as insecticides or rodenticides. Formerly, dangerous substances such as

sodium arsenite and ammonium thiocyanate were used on marsh plants to a limited extent, but they have been largely superseded by herbicides that are safer and fully as effective.

Because gas or vapor drift from some spraying operations has proved harmful to farm crops, there are strict laws[3] on aerial spraying of herbicides. There is also the possibility of injury to nearby stands of duck-food plants. Coarse sprays, such as those released by low-pressure equipment, are much less likely to drift and cause damage to crop plants than fine sprays produced under high pressure. Furthermore, herbicides consisting of salts or low-volatility esters are safer than volatile esters as regards release of toxic vapors from sprayed areas.

2,4-D AND 2,4,5-T

Two of the most popular herbicides in marsh management are the so-called phenoxy compounds, 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid). 2,4-D is cheaper than 2,4,5-T and is used much more widely, but both are comparatively low in cost, and both are effective on many kinds of marsh plants.

Besides their economy and wide effectiveness, formulations of 2,4-D and 2,4,5-T are easy to apply, are somewhat selective in generally being more toxic to broadleaf plants than grasses, and are noncorrosive to spraying equipment. The sensitivity of cotton, tobacco, grapes, tomatoes, and other crops to these chemicals is an important drawback to the use of herbicides in agricultural areas.

The most commonly used formulations of 2,4-D and 2,4,5-T are amine salts and esters. Under favorable conditions, the salts and esters give nearly equivalent results, though generally the former are slower in showing effects. The salts dissolve readily in water but not in oil, handle easily, and their sprays do not volatilize so readily as esters. On the other hand, the fact that esters can be dissolved in oils is an advantage in low-volume spraying, as in aerial applications. Furthermore, oils such as kerosene and diesel oil have some herbicidal value and their use as diluents enables better residual adherence to floating-leaf aquatics like waterlilies or spatterdock and on other plants wet by rain shortly after spraying.

OTHER HERBICIDES

During the past decade, ammonium sulphamate (Ammate) and TCA (sodium trichloroacetate) have been used to a limited extent

[3] Such laws are summarized in Herbicides Law Manual, compiled by the National Agricultural Chemical Association, 1145 19th St., N. W., Washington 6, D. C.

in marsh management. Ammate is effective on many marsh and swamp plants, but it is comparatively expensive. The main usefulness of TCA is on grasses, but in combination with 2,4-D it has proved effective on needlerush. Both Ammate and TCA corrode spraying equipment. The soil sterilants Borascu and Polyborchlorate have been used successfully for local, small-scale eradication of hard-to-control pests in unflooded sites, but costs are likely to be prohibitive for extensive treatments with these chemicals.

A number of promising new herbicides have become available recently. Among these is dalapon (2,2-dichloropropionic acid), sold under the names Radapon and Dowpon. It has shown superiority to 2,4-D for control of phragmites, maidencane, and certain other narrow-leaf marsh plants. ATA (3-amino-1,2,4-triazole) which is sold as Amino Triazole and Weedazol has important possibilities for control of cattails and other plants. It is translocated readily and inhibits chlorophyll production with the result that new growth is often albinistic. Erbon (2-(2,4,5-trichlorophenoxy)-ethyl-2,2-dichloropropionate) has given indication of being valuable as a temporary soil sterilant in sites that are not flooded for two or three months. It is sold under the names Baron and Novon. Certain formulations of silvex, (2-(2,4,5-trichlorophenoxy)-propionic acid) have given encouraging results on alligatorweed, specifically Kuron and 2,4,5-T Propionic. Additional promising new herbicides include urea formulations such as monuron, diuron, and neburon, and certain chlorobenzoic derivatives.

WHEN AND HOW TO SPRAY

In general, herbicides are likely to be most effective under conditions favorable to plant growth—sunny, warm, humid weather. Spraying in early morning or midmorning usually results in good penetration before afternoon or evening showers arrive. Water-soluble herbicides should remain on plants at least 6 hours before a rain. Spraying is easier, safer, and more effective when air movement is limited.

Volume used depends on the method of spraying (from land, boat, or plane), as well as on the height and density of the vegetation treated. Generally, spraying operations from land or boat use 50 to 500 gallons per acre. Good coverage without wasteful runoff requires careful operation with efficient equipment. In many instances, low-volume spraying with large droplets has proved as effective as thorough wetting with fine high-pressure spray. Most commercial herbicides now include wetting agents that increase adherence of sprays to leaves, but sometimes addition

of a detergent or "sticker" is needed to assure wetting of water-repellent foliage. Household detergents and Tergitol 4 are suitable for this purpose, but only enough should be used to give good adherence. Commonly, the adherence of a spray solution is tested preliminarily to appraise adequacy of wetting agents in it.

SPRAYING EQUIPMENT

Efficient herbicidal control of marsh weeds requires equipment adapted to the scale or kind of operation involved. For small-, medium-, or large-scale projects, many makes and types of spraying equipment are available. For small areas and local "spot treatments," single-nozzle hand sprayers are used, either afoot or on boats. Power sprayers mounted on trucks, tractors, or boats are employed commonly on projects of medium or large scale. Usually such spraying outfits have booms with numerous nozzles, but in some instances a single-nozzle hose is attached. For extensive tracts, plane application is practical. This method has, among other merits, the advantage of avoiding difficulties of land or boat travel in soft muck or in areas of interspersed marsh and water. A major part of herbicidal operations on Federal waterfowl refuges now involves airplane spraying.

Air-thrust boats deserve mention here, though their usefulness is by no means limited to weed-control work. These shallow-draft, flatbottom craft driven by airplane propellers have proved practical in weed-control reconnaissance and for spraying in comparatively inaccessible areas, particularly in marshes that are interlaced with shallow waterways.

Publications listed below can be consulted for suggestions on spraying equipment:

1956. Sprayers for Weed Control. William G. Westmoreland and J. C. Ferguson. North Carolina State Ext. Circ. 403.
1951. Weed Spraying Equipment. G. E. Page. Oregon Agr. Exp. Sta. Bul. 493.
1950. When Buying Weed Sprayers Consider Many Points. R. E. Larson and V. H. Johnson. Minnesota Farm and Home Sci., 7(2).
1948. Chemical Weed-Control Equipment. Norman B. Akesson and W. A. Harvey. California Agr. Exp. Sta. Circ. 389.
1948. Spray Equipment for Weed Control. Noel S. Hanson and John Steele. Univ. Nebraska Ext. Circ. 174.

JUDGING RESULTS

Since most marsh weeds are perennials, success or failure of efforts to control them cannot be judged reliably until the following growing season. Furthermore, some herbicides cause inhibition of

growth well into the second year. Impressive top kills or brown-outs produced by certain chemicals are frequently followed by vigorous regeneration from basal parts, either in the same year or the next one. Rapid killing of plant tissues is often disadvantageous by hindering translocation of toxic substances.

Another factor to be considered in judging success of herbicidal operations is the rate at which treated weeds return to dominance. Kinds of weeds that reestablish and spread rapidly need to be eliminated 95% or more, else efforts toward their control will be nullified in a short time.

CALCULATIONS

An important aid in figuring amounts of chemicals required for spray solutions and in determining how to adjust spray equipment to obtain particular dosages per unit area is the Handbook of Weed Control Calculations, by John T. Maletic, USDI Bureau of Reclamation, 1949. Additional help may be available from the following formulas and tables, which were prepared with the help of Clark G. Webster of the Patuxent Refuge.

CALCULATING AMOUNTS OF MATERIALS TO USE

The starting point for ascertaining amounts of ingredients needed in spray solutions is the herbicide's concentration as recorded on the container label. Commonly the concentration is expressed in pounds of acid equivalent or active ingredients per gallon and in percentages of acid equivalent or active ingredients (often referred to as "active"). Having this information, it is possible to determine the amount of commercial herbicide required to make a solution with 1 pound of acid equivalent or active ingredients per 100 gallons or a 1-pound-per-acre application of acid equivalent or active ingredients (table 1), or to make other specific solutions. In preparing solutions other than for 1 pound per 100 gallons or per acre, or for other quantities than 100 gallons, corresponding fractions or multiples of figures in the tables can be computed readily. It is desirable to use acid-equivalent figures when they are available.

USEFUL CONVERSION FIGURES:

1 gallon = 4 quarts = 8 pints = 128 fluid ounces = 3785 milliliters.
1 pint = 2 cups = 16 fluid ounces = 32 teaspoonfuls.
1 tablespoonful = 3 teaspoonfuls = 15 milliliters.
1 fluid ounce = 29.6 milliliters.
1 pound = 16 ounces = 453.6 grams.
1 acre = 160 square rods = 43,560 square feet.

POUNDS-PER-ACRE FORMULAS; MAKING SPRAY SOLUTIONS FOR A PARTICULAR NUMBER OF POUNDS PER ACRE OF ACID EQUIVALENT OR ACTIVE INGREDIENTS:

Using *liquid* herbicide:

The *pints* needed per 100 gallons of solution =

$$\frac{\text{wanted lbs. acid equiv. or act. ingr. per acre} \times 800}{\text{gals. spray per acre} \times \text{lbs. acid eq. or act. ingr. in 1 gal.}}$$

Example: If a 2,4-D formulation containing 4 pounds acid equivalent per gallon is to be applied at 5 pounds acid equivalent in 120 gallons of solution per acre, the pints needed per 100 gallons of solution are:

$$\frac{5 \times 800}{120 \times 4} \text{ or } 8.3 \text{ pints}$$

The *milliliters* needed per gallon of solution =

$$\frac{\text{wanted lbs. acid equiv. or act. ingred. per acre} \times 3785}{\text{gals. spray per acre} \times \text{lbs. acid eq. or act. ingr. in 1 gal.}}$$

Using *solid* (dry) herbicide:

The *pounds* needed per 100 gallons of solution =

$$\frac{\text{wanted lbs. acid equiv. or act. ingred. per acre} \times 100}{\text{gals. spray per acre} \times \% \text{ acid eq. or act. ingred.}}$$

Example: If a formulation of dalapon containing 71% acid equivalent is to be sprayed at the rate of 30 pounds acid equivalent in 200 gallons of solution per acre, the pounds of herbicide needed per 100 gallons of solution are:

$$\frac{30 \times 100}{200 \times .71} \text{ or } 21.1 \text{ pounds}$$

POUNDS-PER-100-GALLONS FORMULAS; MAKING SPRAY SOLUTIONS WITH A PARTICULAR NUMBER OF POUNDS OF ACID EQUIVALENT OR ACTIVE INGREDIENTS PER 100 GALLONS:

Using *liquid* herbicide:

The *pints* needed per 100 gallons of solution =

$$\frac{\text{wanted lbs. acid equiv. or act. ingred. per 100 gals.} \times 8}{\text{lbs. acid equiv. or act. ingred. in 1 gal. herbicide}}$$

Example: If a 2,4,5-T formulation containing 4 pounds acid equivalent per gallon is used to prepare a solution with 5 pounds acid equivalent per 100 gallons, the pints needed per 100 gallons are:

$$\frac{5 \times 8}{4} \text{ or } 10 \text{ pints}$$

Using *solid* (dry) herbicide:

The *pounds* needed per 100 gallons of solution =

$$\frac{\text{wanted lbs. acid equiv. or act. ingred. per 100 gals.}}{\% \text{ acid equiv. or act. ingred. in the herbicide}}$$

Example: If an Ammate formulation containing 95% active ingredients is used to prepare a solution with 60 pounds active ingredients per 100 gallons of solution, the pounds per 100 gallons are:

$$\frac{60}{0.95} \text{ or } 63.2 \text{ pounds}$$

TABLE 1.—*Amounts of herbicide needed for certain solutions*

To make a solution for a 1-pound-per-acre application of acid equivalent or active ingredients:

When using a formulation with one of the following strengths (representative of important herbicides):			Then the amount of commercial herbicide needed for one acre in:			
	Percent of—		Liquid measure:		Dry measure:	
Pounds of acid equiv. or act. ingr. per gal.	Acid eq.	Act. ingr.	Fluid ounces	Pints	Ounces	Pounds
4			32	2		
3.34			38	2.36		
	71				22	1.41
	79.3				20	1.26
		50			32	2.
		95			16.8	1.05

To make a solution with 1 pound of acid equivalent or active ingredients per 100 gallons or per 1 gallon:

When using a formulation with one of the following strengths (representative of important herbicides):			Then the amount of commercial herbicide needed for:			
	Percent of—		100 gallons:		1 gallon:	
Pounds of acid equiv. or act. ingr. per gal.	Acid eq.	Act. ingr.	Pints	Pounds	Fluid ounces	Ounces
4			2		0.32	
3.34			2.38		0.38	
	71			1.41		0.22
	79.3			1.26		0.20
		50		2.		0.32
		95		1.05		0.17

CALCULATING SPRAY APPLICATIONS

[Based largely on Suggested Guide for Chemical Control of Weeds, U. S. Agr. Res. Service Special Report 22–23, April 1956. Useful information on calculations and procedures in aerial spraying is given in How to Spray the Aircraft Way, USDA Farm. Bul. 2062, June 1954.]

The amount of herbicide delivered to a sample unit or area can be determined preliminarily by a test run using plain water in the spray tank. The method is applicable to various types of equipment under particular conditions of nozzle adjustment, tank pressure, and rate of progression. When a known acreage, fraction of acreage, or other unit of area has been sprayed during a test run, the amount of water used can be ascertained by measuring the quantity required to refill the tank. In making calculations for different operations, rate of progression or nozzle adjustment may need to be altered if plants to be sprayed are of different height or density.

The number of gallons per acre applied by a power sprayer, at a given setting of nozzles, tank pressure, and rate of progression, can be determined after a 220-yard test run as follows: Multiply the number of gallons used by 66 and divide the product by the number of feet in the sprayed strip width. Similarly, for a 110-yard test, multiply the gallons by 132 and divide by the number of feet in the sprayed strip width.

The number of pints per acre applied by a full 3-gallon hand sprayer can be calculated by testing on a 10 x 10 foot (100 square feet) area as follows: ½ pint applied to 100 square feet equals 27 gallons per acre, 1 pint equals 55 gallons per acre, and one quart equals 110 gallons per acre. Accordingly, if one wishes to apply 1 pint of commercial weed killer per acre, it should be mixed with: 27 gallons of diluent if the sprayer applies ½ pint to 100 square feet, 55 gallons of diluent if sprayer applies 1 pint to 100 square feet, and 110 gallons of diluent if the sprayer applies 1 quart to 100 square feet.

MECHANICAL CONTROL

Besides mechanical equipment used in spraying, machinery of several types is of practical value in controlling weeds in marshes and swamps and in converting such areas into cultivated fields or marshes attractive to waterfowl. Equipment for such purposes includes bulldozers for felling woody plants, rotary brush cutters, heavy harrows, disks, and rototillers for conditioning soil that contains masses of tough roots, and mowers or crushers for control of coarse marsh weeds. A principal limiting factor to wider use of such equipment is its inability to function well on soft, boggy

land or in places that include combinations of marshland and water. So-called marsh buggies with their enormous, expensive tires are only a partial answer to the need. If in the future a practical land-water vehicle of the "rollagon," "rhino," "weasel," or marsh-buggy type comes into commercial production, there may then be more extensive use of mechanical equipment for weed control as well as for other marsh-development programs.

Heavy machinery of the bulldozer, disk, and harrow type is being used on many Federal and State waterfowl refuges to produce planted food crops for the birds in marshy or swampy areas. This appears to be one of the most practical ways of combating persistent marsh weeds such as are particularly prevalent in the Southeast.

Cutting of weeds with hay mowers and rotary mowers is feasible on marshes that are not too wet. However, such mowing usually needs to be timed at particular stages of growth if control of the species is to be more lasting than the mowing of grass in a lawn. Generally, crushing by special rollers or by tractors with wide cleats is more likely to be effective in controlling marsh plants than is cutting. Crushers devised and used by mosquito-extermination organizations in certain New Jersey counties have been operated successfully for marsh management for many years.

BURNING

By itself, fire is generally an ineffective control for marsh weeds. Indeed, it sometimes favors undesirable species by removing excessive shading or other handicaps contributed by their own dead stalks. However, fire can be an important adjunct to other means of control, particularly in herbicidal treatment of dense growths such as needlerush and phragmites. Preliminary burning in late winter or spring enables more efficient use of herbicides by avoiding wasting of the spray on dead stems. Burning several months after treatment can also be beneficial by helping to eliminate weeds that survive spraying and by opening up growing space for desirable plants. Wilson[1] found that burning of needlerush in winter in North Carolina, following an apparently unsuccessful herbicidal treatment earlier in the year, resulted in complete kill of the plants. Myers[1] working with the same species in Florida not only demonstrated the value of preliminary burning to increased efficiency of control by mowing or by herbicides but also demonstrated that

[1] See references under Needlerush on page 34.

burning after treatment was beneficial provided it was delayed until fall. Burning preliminary to herbicidal treatment of regrowth is practiced in California on dense growth such as phragmites and cattails. In tidal marshes, burning at intervals of 1 to 3 years has been found beneficial in controlling bushy growths.

BIOLOGICAL CONTROL

The only instances of man-arranged biological control in marshes occur where muskrats, nutria, or livestock have been allowed to reduce undesirable stands of plants. Cattail is plagued by stem borers, lotus by leaf beetles, and other weeds by their special parasites, but at present man has not developed methods of capitalizing on the usefulness of these minute control agents for marsh management.

MARSH WEEDS

Under the heading Marsh Weeds, 17 of the more important herbaceous pests of waterfowl habitat are discussed alphabetically by their common names. Besides species that are typical marsh plants, waterlilies, waterhyacinth, and other aquatics having leaves at or above the water surface are included since their dense stands are often implied in the designation "marsh." Their foliage is sprayed with herbicides in much the same way as other marsh plants, and in this regard they are distinct from submerged aquatics. Swamp-inhabiting trees or shrubs are discussed under Woody Weeds on page 52.

ALLIGATORWEED

BOTANICAL

The genus *Alternanthera* (also listed as *Achyranthes*) is largely tropical but includes half a dozen species in the Southeast. Only one member of the group, alligatorweed, (*A. philoxeroides*) also called alligatorgrass or pigweed, is a serious pest in this country. Besides having wide distribution in Central and South America, it occurs along our lower coastal plain from Texas to North Carolina. An infestation that appeared in the TVA area about 1933 has persisted and spread. In 1955, beds of alligatorweed were found at Moyock, N. C., near Currituck Sound and the Virginia line, the northernmost point of infestation thus far. Infestations in Los Angeles, Calif., have recently been reported.

It reproduces and spreads mainly vegetatively; seeds are not known to be produced in this country. Broken-off branch fragments root readily, and stems may elongate as much as 200 inches in one season. Alligatorweed grows rooted in mud but often extends considerable distances over water surfaces. It is tolerant of flooding and, though mainly a fresh-water plant, endures mild salinity.

IMPORTANCE

Alligatorweed is eaten some by baldpates, gadwalls, coots, muskrats, and nutrias, and to a limited extent by hogs and cattle, but it has no value that compensates appreciably for its detriment It is one of the worst pest plants of the Southeast, obstructing navigation in canals, bayous, and lakes, destroying beds of duck foods, ruining fishing areas, and causing a serious malaria hazard in some localities.

CONTROL

During the past quarter of a century, effective control of alligatorweed has remained an unsolved problem. Various methods and means tried have proved costly and unsatisfactory. Recently, however, certain new herbicides have given indication of usefulness for this purpose. Sterilants such as erbon have shown promise in unflooded sites, and several new herbicides, both alone and in combinations, have given encouraging results on alligatorweed in flooded places.

Among sites or conditions in which control is especially difficult are continuously flooded waterways, growths partially buried under silt, and heavily matted beds. Alligatorweed on unflooded flats or on dikes can be killed somewhat more readily. Because of the plant's ability to reinvade rapidly, control needs to be complete or nearly so.

Crushing, cutting, and mechanical removal of beds, as was done extensively in Louisiana formerly, provided expensive and only temporary opening of waterways that were clogged by alligatorweed. Though subsequent use of 2,4-D for this purpose reduced operational costs, it too contributed comparatively little toward extermination or enduring control of the plant in extensive areas. The cooperative study conducted from 1948 to 1950 by the Boyce Thompson Institute, the Corps of Engineers, and Tulane University reported that 2,4-D (preferably the amine salt) applied at 8 pounds per acre during the season of less active growth, from July to the following spring, gave nearly complete control of beds extending over water in experimental pools. However, general experience elsewhere with 2,4-D treatment has been discouraging. Usually, only temporary setback has resulted.

During the past few years, several new chemicals have been tested on alligatorweed at waterfowl refuges in the Southeast, and cooperative studies by the State of North Carolina and the U. S. Fish and Wildlife Service have tried numerous new compounds, both alone and in various mixtures, on more than 100 experimental plots in that State. Some of the more promising treatments are indicated below under subheadings that denote the type of site.

IN FLOODED SITES

Treatments with the Weedone 2,4,5-T Propionic form of silvex at 40 pounds acid equivalent and neburon at 32 active per acre have given good results. Mixtures of chemicals also have been encouraging in some instances, the combinations proving to be more effective than twice the amount of either component used separately. Following are some of the more promising mixtures with indication of poundage per acre of acid equivalent or active ingredients: neburon at 16 with the Kuron form of silvex at 20; TBA mixture at 6 with silvex at 20; dalapon at 33 with silvex at 20.

IN UNFLOODED OR TEMPORARILY DRAINED SITES

Erbon has given effective control in North Carolina and elsewhere with dosages of 40 pounds active per acre, and in some cases as low as 20 pounds active, providing flooding does not occur for 2 months after treatment. Best results were obtained by treating during the period of active growth. The sterilant effect of erbon at these dosages disappears largely or entirely within 3 months.

ATA at 10 pounds applied at different stations during maximum flowering has given inconsistent results. At 2 or 3 tons per acre, Polybor-chlorate, Borascu, or sodium chlorate are capable of eliminating alligatorweed in moist or comparatively dry places.

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ARROW-ARUM

BOTANICAL

Arrow-arum (*Peltandra virginica*) is widely distributed in the East and is particularly plentiful in fresher parts of tidewater sections of streams and bays along the Atlantic Coast. It is a coarse perennial that spreads mainly by means of its fleshy-coated seedlike berries. Its large arrow-shaped leaves can be distinguished from those of arrowheads and pickerelweed by the fact that the latter two have all their main veins radiating from one point near the base of the blade whereas in arrow-arum, several main veins branch out from the midrib. Another species of arrow-arum, *P. glauca,* having a white spathe and red berries, is restricted to the South.

IMPORTANCE

The large seedlike berries are eaten by wood ducks, and this may explain the local name duck-corn. In many places it is a weed, using space that could be occupied by more desirable plants.

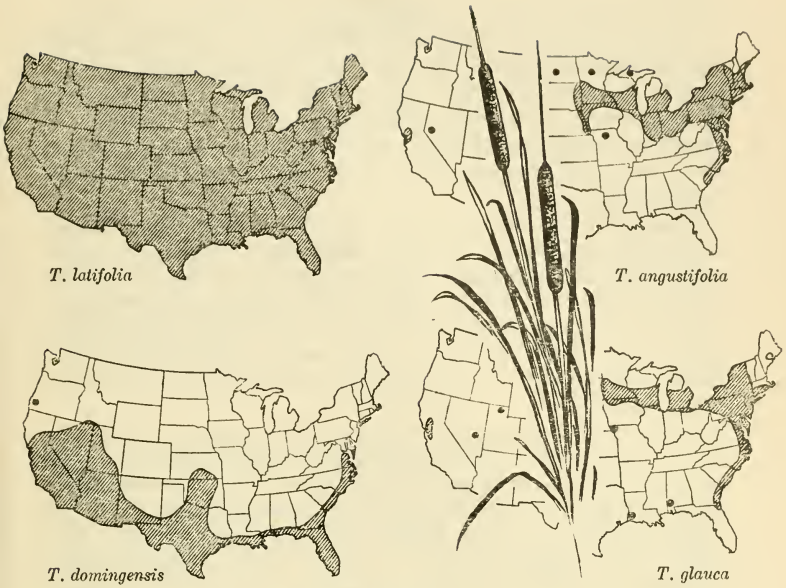
CONTROL

Complete spraying of foliage with 2,4-D (either salt or ester) at a concentration of 6 pounds per acre during the flowering and early fruiting period has given effective control in Delaware. In that State, the most susceptible stage occurs in the first half of June.

REFERENCE

1954. The Marshes of Delaware, Their Improvement and Preservation (p. 34). John H. Steenis and others. Del. Board of Game and Fish Comm.

CATTAILS



BOTANICAL

This worldwide genus (*Typha*) has four species in the United States, as mapped and named above. Cattails, also called flags or tules, often dominate extensive marsh areas. They spread rapidly by means of rootstocks and also by means of minute, airborne seeds which germinate readily on mud flats and occasionally in shallow, clear water. The seeds can remain viable for at least 5 years.

IMPORTANCE

Cattails are excellent food and housebuilding material for muskrats, are eaten by nutria, serve as food to a limited extent for ducks and geese in some localities, and provide nesting sites for several species of waterfowl and rails; the leaves have commercial value for mats, chair seating, thatching, and barrel calking; and the fluff from heads has been used as a substitute for kapok. On the debit side, cattails are among the most widespread and abundant weeds of waterfowl habitat and are serious pests on western irrigation ditches.

CONTROL

Cattail stands can be controlled effectively by herbicides, mowing, or other mechanical means. The species of cattail and the local habitat conditions commonly have a bearing on effectiveness of treatments. In general, the optimum stage for treatment is about the time flowers of the staminate spike are drying. On limited areas, invading seedlings can be eliminated effectively by hand pulling.

New herbicides, particularly ATA and dalapon, have largely supplanted 2,4-D in recent control operations. Though 2,4-D was used widely for this purpose formerly, it was not particularly satisfactory since a number of retreatments have usually been necessary. Tests with the new herbicides will need to be continued for several more years before positive conclusions can be made about the best method of treatment for the different species in different environmental conditions.

ATA has given uniformly good to excellent results in California (Citrus Experiment Station, Riverside) and Maryland (FWS Patuxent Research Refuge, Laurel) at rates of 5 to 10 pounds active ingredient per acre. Dalapon at 20 pounds acid equivalent has given complete control in Michigan tests (Grigsby et al., 1955) and at the St. Marks Refuge in Florida, but in a Maryland site periodically flooded by tidewater 40 pounds failed to kill all of the plants. At present it appears that dalapon is much more likely to be effective on comparatively dry sites than in flooded habitats. In southern California, two dalapon treatments (May and September) at 10 pounds each, followed by midwinter burning of dead stems, failed to prevent considerable regrowth of cattails. Mixtures of ATA (50% commercial formulation) and dalapon (85% commercial formulation) at respective approximate poundages of 3 and 6 have been used in 100 gallons of water applied at the rate of 400 to 500 gallons per acre in southern California.

Cutting cattails close to the ground at two special stages of growth in the same season resulted in 90% to 100% control in Maryland, Tennessee, and Utah tests. The first cutting should be made when pistillate spikes are well formed and at least two-thirds full size but not mature enough to scatter viable seeds; the second about a month later, after regrowth has attained a height of about 2 feet. Cutting at other times was found to reduce greatly the percentage of kill. Success is likely to be greater in areas where water is present and covers the cut stem-bases, yet even where water is absent much of the time, as in some tidal or

inland cattail marshes, mowing at the two specified stages can give complete or practically complete control. The procedure has been demonstrated successfully in various parts of the country, but its use on a large scale requires mechanical equipment adapted to mowing in marshy areas.

Mechanical crushing or breaking of cattail plants has given results largely equivalent to those obtained by cutting. Drowning (without cutting) is possible if bases of stems are submerged by 4 feet or more of water for more than 1 year, except for *T. domingensis* which can endure slightly higher levels. Biological control favoring use by waterfowl may result from "eat-outs" in cattail marshes by muskrats or nutria. A limited degree of natural control has been caused by a boring-moth larva (*Arzama* sp.). In some instances, it has seriously damaged or entirely eliminated dense cattail stands.

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COCKLEBUR

BOTANICAL

A recent classification of the cocklebur genus, *Xanthium*, places all of the common broadleaf forms under the one species *X. strumarium*, but some botanists still recognize numerous species. These coarse annuals grow in a wide variety of sites including fields, roadsides, and different types of waste places, but they become especially abundant on exposed floodplains of impoundments subject to drawdown. The prickly burs bear two seeds.

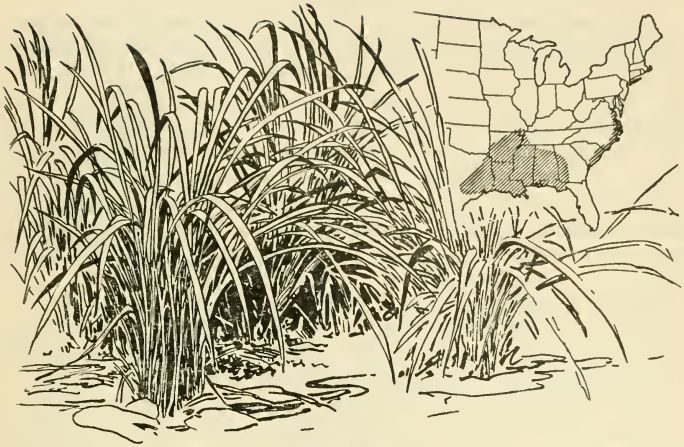
IMPORTANCE

Rank growths of the plants on flood plains and impoundment margins often occupy space that would support duck-food plants. Also seedlings in the cotyledon stage are reported toxic to livestock. In their favor is the fact that seeds of cockleburs are eaten to a limited extent by mourning doves.

CONTROL

Cockleburs can be killed readily by herbicides. Formulations of 2,4-D are effective at the rate of ½ pound acid equivalent per acre. Recent tests at the Tennessee National Waterfowl Refuge have indicated that silvex gives satisfactory results at ¼ pound per acre. Also, complete flooding for 12 to 15 days has been found to kill cockleburs.

GIANT CUTGRASS



BOTANICAL

Giant cutgrass *Zizaniopsis miliacea*, also called whitemarsh, is a tall perennial of semitropical America that extends northward a short distance beyond the southeastern Coastal Plain. It grows in freshwater coastal marshes from Virginia to Texas and is particularly abundant in former ricefields of South Carolina and Georgia. Giant cutgrass also occurs inland in the Lower Mississippi Valley region as far north as Reelfoot Lake in Tennessee, where it covers nearly 2,000 acres.

This weedy grass grows on moist soil or in water up to 3 feet deep, and for limited periods it tolerates deeper water. Its seeds —generally produced rather sparsely—germinate readily on moist mud flats. Runners are the principal means of spread, especially in flooded areas. In late summer, stolons or runners develop freely from the lower parts of the plant, some of them attaining a length of 14 feet. Leafy buds and roots produced at nodes of the runners establish independent plants at some distance from the parent, and in this way giant cutgrass spreads over both flooded and unflooded sites.

IMPORTANCE

Waterfowl feed on giant-cutgrass seeds where they are plentiful and readily available, as along margins of openings of the marsh, or where the growth is sparse. Such value, however, is slight compared to its detriment to waterfowl habitat; the plant's aggressive growth and saw-edged leaf blades make it one of the most troublesome marsh weeds in the South.

CONTROL

Giant cutgrass is difficult to kill, and no fully satisfactory, economical way has been found to control it despite nearly a decade of experimentation at Reelfoot Lake and elsewhere. Within limited areas, complete elimination is possible, but generally it is difficult and costly. Methods of control used and the extent of their effectiveness depend considerably upon whether standing water is present. Degree of success also depends on whether treatment is made during the most vulnerable stage, which is in late summer or early fall, during maximum runner growth. This susceptible stage occurs about 2 months after the main period of flowering.

CONTROL ON DRAINED AREAS

Growing on land, giant cutgrass can be reduced or largely eliminated by disking, grazing, or by herbicides. Winter freezing kills the plants, particularly if preceded by dewatering and burning.

On drained sites, dalapon seems superior to TCA, Polybor-chlorate, Chlorax Liquid, silvex, 2,4,5-T and several other herbicides tested. At rates of 70 to 199 pounds acid equivalent per acre, dalapon applied during the vulnerable period has given good to excellent control. Monuron at the rate of 100 pounds active per acre has been effective in controlling giant cutgrass on moist land not subject to moving water.

CONTROL IN FLOODED AREAS

At Reelfoot Lake complete foliage coverage by Ammate at the rate of 170 pounds active or by Polybor-chlorate at 200 to 300 pounds per acre during the vulnerable period has yielded good to excellent control. Of the newer herbicides, dalapon applied at the rate of 140 pounds acid equivalent per acre proved effective. The results from treatments with silvex and certain other herbicides have been inconclusive.

Underwater cutting can, under favorable circumstances, yield at least a 90% kill, but the method has practical limitations for extensive application. For best results, the cutting must be done in the vulnerable period and should be in at least 6 inches of water. A commercial underwater mower tested for this purpose proved impractical since it could not operate in water less than 16 inches deep and was unable to cut the tough stems of plants over 30 inches tall. Allowing cut stems to remain where they fall appears to increase the percentage of kill. Mowing at other than the vulnerable stage is comparatively ineffective.

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HIBISCUS

BOTANICAL

This warm-climate genus of nearly 200 species has about 20 to 25 native representatives in the United States. Because of their showy flowers, various kinds of exotic hibiscus are cultivated as ornamentals in warm regions of the country. Only two or three species are significant as weeds in waterfowl habitat, though several others occur in marshes. The plants are perennials that regenerate from basal buds in the spring. Their large seeds germinate abundantly on mud flats exposed by receding water.

H. moscheutos, here treated as including *palustris* and *oculiroseus*, is the most important weedy hibiscus. It grows in fresh or mildly brackish marshes from Massachusetts to Texas and occurs inland locally in the East. In some localities the plant is a weed of major importance. Its local names are rosemallow, hibiscus, hollyhock, and marshmallow.

H. militaris is primarily an inland species, occurring from Pennsylvania, Minnesota, and Nebraska, south to Florida and Louisiana. Its chief abundance is along river margins and in adjoining areas subject to periodic overflow. *H. lasiocarpos* also grows inland, sometimes associated with *H. militaris*. Saltmarsh mallow, *Kosteletzkya virginica*, is common in Atlantic and Gulf Coast marshes but generally has lesser consequence as a weed.

IMPORTANCE

Hibiscus plants provide nesting sites for some marsh songbirds

and have attractive flowers, but there is little else to recommend them. Their seeds are seldom eaten by ducks or other wildlife, and locally the plants are serious weeds in waterfowl and muskrat habitat.

CONTROL

Experiments on eradication of this weed in Delaware and Maryland have shown that effective control can be obtained by moderately light dosages of 2,4-D, by underwater cutting, or by drowning. Valuable duck-food plants have become established in test plots where hibiscus was eliminated. Reinfestation should be prevented by avoiding, if possible, continuous drawdown during the growing season. Where protracted lowering of levels is unavoidable, temporary reflooding of the area will drown the seedlings.

HERBICIDES

Tests on *H. moscheutos* have indicated that 2,4-D (about 6½ pounds per acre, 0.5% concentration, and 160 gallons per acre) gives about 95% control if applied during full-flowering or early-fruiting stages. Also, treatments with a mixture of 2,4-D at 4 pounds and TCA at 50 pounds per acre have given consistently good control. Results have been nearly the same on *H. militaris*.

DROWNING

Mature plants of *H. militaris* and *H. lasiocarpos* at Isom Lake, Tenn., were drowned by a permanent 3-foot rise in water level. Similar results have been obtained in TVA impoundments. In the Thousand-Acre Marsh near Delaware City, Del., *H. moscheutos* was nearly eliminated by an increase in water level varying from 15 to 30 inches and lasting about a year.

Seedlings can be controlled readily by drowning. In Delaware it was found that hibiscus seedlings can be drowned without destroying seedlings of desirable species such as smartweeds and Walters wild millet.

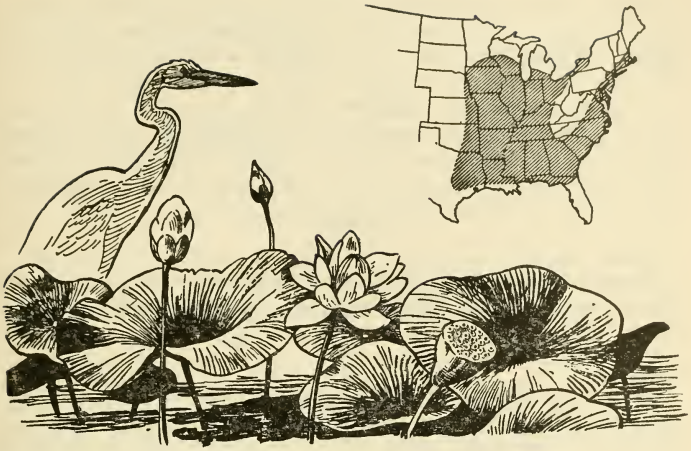
CUTTING

Small-scale tests on cutting of hibiscus by sickles in Delaware and Maryland have shown that if the cut bases are submerged continuously, one mowing can give a high degree of control. In other situations, two cuttings may eliminate 95% or more of the plants. The two cuttings may be timed 1 to 1½ months apart, or the second cutting may even occur in the following year and still be nearly equally effective.

REFERENCE

1954. The Marshes of Delaware, Their Improvement and Preservation (p. 35). John H. Steenis and Others, Delaware Board of Game and Fish Comm.

LOTUS



BOTANICAL

The native yellow-flowered lotus, *Nelumbo lutea*, also called yonkapin, yonkanut, bonnets, or water chinkapin, is common in ponds and lakes of the Mississippi Valley and occurs widely in the East. A pink-flowered Asiatic species, *N. nucifera*, has been introduced in various places but thus far has shown no tendency to become a problem plant.

This umbrella-leafed aquatic grows in water up to 8 feet deep. It tolerates drops in water level, but a sudden rise covering leaves for at least 12 days will kill mature plants. Vegetative spread by runnerlike rootstocks is rapid—about 250 feet of new growth in 1 year has been reported. Banana-shaped tubers, filled with starchy food, are borne on the runners. The acornlike seeds may germinate shortly after maturity or may remain dormant and viable for hundreds of years.

IMPORTANCE

A few species of ducks such as wood ducks and teal feed on lotus seeds to a limited and generally insignificant extent—mainly in late summer before the seedcoat has hardened. Tubers and seeds were formerly eaten by Indians. In many localities the plant is a serious pest, covering ponds with its rank vegetation and precluding good growths of desirable duck-foods.

CONTROL

Control can be accomplished rather easily, by herbicides, drowning, or mowing. The best time is the summer season, when the plants are flowering freely. Eradication must be complete, else rapid spread of surviving plants may soon reestablish beds.

In some localities, a biological means of control is evident; larvae of the leaf beetle *Donacia hypoleuca* bore into petioles below water level and sometimes destroy extensive beds in deep water. Only once in a total of 10 years did this insect provide conspicuous control of lotus at Reelfoot Lake in Tennessee.

HERBICIDES

A single herbicide spraying of 2,4-D (either salts or esters) at 2 to 4 pounds of acid equivalent per acre can give nearly complete control of lotus.

DROWNING

Where water levels can be managed readily, drowning of lotus is the easiest and most economical control procedure. A rapid rise of 30 to 36 inches (to cover the leaves) is needed and must be maintained at this high stage for at least 12 days. Plants are more susceptible when flowering freely. Turbidity of water also increases effectiveness. Drowning of lotus sometimes occurs naturally, after heavy rains and flooding.

CUTTING

In general, mowing of lotus is likely to be less practical than the use of 2,4-D. Underwater mowing of leaf and flower stalks in shallow water, less than 2½ feet deep, is generally ineffective. In water 3 to 5 feet deep, 80% to 100% control has been obtained by two cuttings. Occasionally, as when the water is dark, one cutting may be sufficient. A commercial weed cutter tested in Reelfoot Lake was found to be impractical for this purpose because of stumps or snags present.

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1944. The Biology of the American Lotus, *Nelumbo lutea* (Willd.) Pers. Thomas F. Hall and William T. Penfound. American Mid. Nat. 31 (3).

MAIDENCANE

BOTANICAL

Of the 170 *Panicum* species listed in the United States, maidencane, *P. hemitomon*, is the most serious pest plant in waterfowl habitat. In this country, it is confined almost entirely to freshwater marshes of the South Atlantic and Gulf Coasts. In Louisiana, where the plant is known as paille fine or canouche, it constitutes a large proportion of the sod in floating marshes.

Maidencane grows on moist soil or in shallow water. Many aerial stems are sterile, but limited seed production is offset by rapid growth of rootstocks.

IMPORTANCE

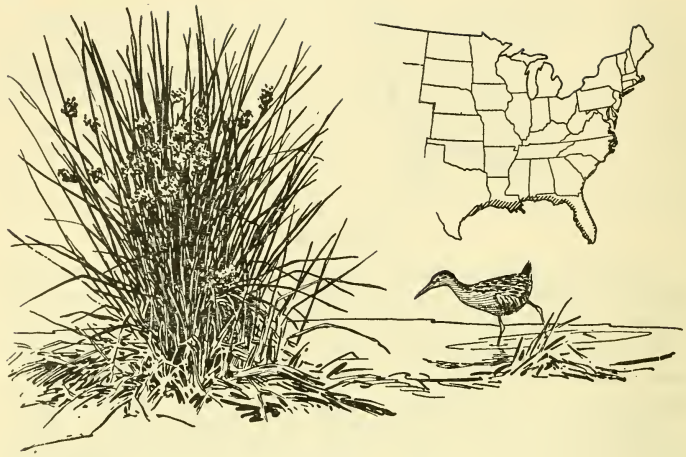
The plant has some value to muskrats for housebuilding and food and is eaten by nutria, but much more significant is the fact that it is a hard-to-control competitor of duck-food plants in the South.

CONTROL

Because of its rapid spread by rootstocks, control of maidencane needs to be complete or practically so. It is more difficult to destroy when growing in water than on drained land.

At present, the most promising prospect for effective control of maidencane has come from recent preliminary tests with dalapon on Federal refuges in the Southeast. At 20 pounds acid equivalent per acre, in early treatments (late March or April) at the Savannah (Ga.) and Loxahatchie (Fla.) Refuges, it has given complete or nearly complete kills. Older chemicals such as 2,4-D, TCA, and Ammate have proved impractical because of large amounts required, and 1 to 3 tons of soil sterilants such as Borascu or Polybor-chlorate are needed for extermination in dewatered units. On drained sites, maidencane can be eliminated largely or entirely in the course of a couple of years by a series of diskings or by diskings combined with herbicide treatments.

NEEDLERUSH



BOTANICAL

Many kinds of rushes (*Juncus*) grow on moist soil or in water in various parts of the United States, but needlerush (*J. roemerianus*) is the only one of major importance as a weed in waterfowl habitat. This tall, needle-pointed plant dominates thousands of acres of brackish coastal marshlands from Maryland to Texas. It is perennial and spreads by rootstocks as well as by seeds. The common rush (*J. effusus*) frequents meadows and other moist sites but generally is of lesser importance as a weed.

IMPORTANCE

Needlerush provides excellent cover for rails and is also useful as cover for black ducks and other waterfowl in some places. However, its minute seeds are eaten only rarely by ducks, and in many marshes it limits usefulness of the habitat for waterfowl and muskrats.

The weed status of this plant varies in different marshes or in different parts of the same marsh. Besides being beneficial as cover in some flooded sites and detrimental in many others, it is neither harmful nor useful wherever standing water is so limited in extent or duration that waterfowl would not use the area even if needlerush growths were destroyed.

CONTROL

Studies on needlerush control have yielded encouraging results, but much remains to be learned about best methods to use in different places and about prospects for suitable replacement. Indications are that the plants cannot spread or reestablish as readily in sites flooded most of the time as compared with better-drained locations. The most vulnerable period is in the spring, during flowering and early stages of fruiting.

Different results have been obtained in different places with similar control treatments, as indicated in the three main areas of needlerush study: North Carolina, Florida, and Maryland. The variations in susceptibility appear to depend on both regional and localized factors. Another peculiarity in the response of needlerush to chemicals is the fact that herbicidal concentrations have to be increased when applying a large gallonage per unit area, as with power sprayers. This contrasts with the usual situation with marsh plants in that ordinarily the requirements for poundage of herbicides per unit area remain the same regardless of carrier volume.

In North Carolina, 27 pounds acid equivalent of 2,4-D isopropyl ester per acre were required for effective control (Barber, 1952). At the Chassahowitzka Refuge in northern Florida, 95% to 99% elimination of needlerush resulted from airplane treatment using 16.7 pounds acid equivalent of 2,4-D ester in 5 gallons per acre (Myers, 1955). In Maryland, both salt and ester formulations of 2,4-D have yielded over 95% control at rates as low as 14 pounds acid equivalent per acre in 200 gallons of carrier (either water or oil) when applied during the vulnerable period (Steenis, Webster, Nicholson, 1954).

The Maryland tests involved use of hand-pressure cylinder sprayers. Treatments at other than the vulnerable period gave erratic results. Slightly superior results were noted with 2,4-D esters in oil, probably owing to better coverage plus some herbicidal effect of the oil. TCA alone was not satisfactory for needlerush control but with a combination of 2,4-D at 8 pounds acid equivalent per acre and 25 pounds of TCA the results were better than with 2,4-D alone. In treatments with 2,4-D alone by power-sprayer equipment, using over 400 gallons of water per acre, it was found necessary to increase the herbicidal concentration to 27 pounds per acre. Also in mixed treatments with a power sprayer, it was necessary to increase the concentration of 2,4-D to 14 pounds per acre and TCA to 50. Monuron, acting as a soil sterilant, was used successfully at 20 pounds active per

acre in areas where there was no extensive water movement for 3 months following treatment. Dalapon showed limited promise at rates of 45 pounds or more active per acre. Mixtures of it with other herbicides have not been tried on needlerush.

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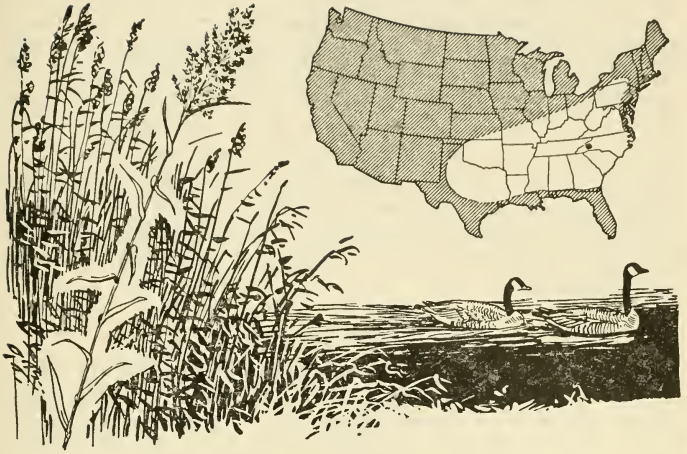

BOTANICAL

Phragmites (*Phragmites communis*) is a tall, plumed marsh grass native to Asia, Africa, and Europe as well as to North America. Though widespread in this country, it is largely absent from the Southeast, except in gulf-coast marshes. Local names include giant or common reed, cane, feathergrass, or foxtail (north Atlantic coast), roseau or roseau cane (Louisiana and eastern Canada), and carrizo or carrizo cane (Southwest).

Dense stands of this robust perennial sometimes extend over many acres. The plant spreads mainly by long runners either underground or aboveground. In shallow water, phragmites can extend its growth if the runners are able to obtain anchorage. Above-ground runners have been known to grow 25 feet in 1 year. It had been assumed that the plants produce viable seed only rarely, yet seedlings have been noted commonly in the Middle Atlantic Region.

IMPORTANCE

Margins of phragmites beds or stands that are not too dense may provide useful cover for waterfowl and locally they serve as cover for pheasants, rabbits, and other game. Runners and aerial stems have some usefulness as food for muskrats and are valuable for their house-building. Hunters frequently make duckblinds

with the stems. In the Southwest the plant has been used for thatching, matting, cordage, and nets.

On the debit side, phragmites is one of the most common weeds in waterfowl habitat and one of the most difficult to control. Though most stands of this plant occur on comparatively high, dry parts of marshes, above the important zone for duck foods, it is also a serious competitor with useful plants, particularly in areas where water levels are not constant. Once established on dewatered flats, it is likely to persist indefinitely and has been known to survive in water a foot or more deep for at least 8 years. In the West, phragmites is a pest along irrigation canals, and in various parts of the country it is a serious fire hazard near industrial installations.

CONTROL

Destruction of phragmites is difficult because of its tough, durable rootstocks. Killing the aerial stems by burning, mowing, or spraying frequently results in only a temporary setback. The plant is particularly resistant to control measures when it is growing in water. Its most vulnerable stage for treatment is during the time of pollen release, a 3–week period occurring in midsummer to early fall depending on location. In most cases, best results have been obtained by treatment during the vulnerable period, but the effectiveness of dalapon is not limited to this season.

Dalapon and ATA, either alone or in combinations, have recently shown ability to control phragmites effectively. Ammate and 2,4-D have proved unsuitable for this purpose, and TCA, though better, is not satisfactory. On comparatively dry sites, phragmites can be eliminated by repeated mechanical operations, such as disking.

HERBICIDES ON COMPARATIVELY DRY SITES

Dalapon treatments have given good results on terrestrial stands of phragmites at various times during the growing season from spring when new shoots are about 3 feet high until early fall when the plants are full grown and in their most vulnerable stage. Application of 30 to 35 pounds acid equivalent of dalapon at any time during this 3- to 4-month period has provided good control. ATA at 16 pounds active per acre was also effective if applied during the pluming-flowering stage, a period of 4 to 5 weeks. A mixture of dalapon at 15 pounds and ATA at 2 pounds has given good kills at various stages of growth, from early to

late summer. The soil sterilant, erbon, was successful at 40 pounds active per acre, and monuron at the rate of 40 pounds active per acre was fairly effective if disked into the ground. Operational programs using dalapon or mixtures of dalapon and ATA applied in approximately 400 gallons of water per acre by power sprayers are now being conducted in New York, New Jersey, and Delaware.

HERBICIDES ON FLOODED OR CONTINUOUSLY WET SITES

Dalapon alone has proved unsatisfactory in flooded habitat, regardless of poundage used or stage of plant growth. However, treatment with dalapon at 25 to 35 pounds combined with ATA at 8 to 10 pounds gave good results when done during the vulnerable stage. ATA alone was sometimes successful when used at 20 to 24 pounds in the vulnerable period. A recent airplane treatment with a mixture of dalapon and ATA in 15 to 20 gallons of water and using triethanolamine as dispersion agent has given encouraging indications. This method of control can have special importance as a means of reducing or eliminating phragmites in comparatively inaccessible flooded areas.

MECHANICAL METHODS

A mowing of phragmites in August 1951, followed by burning and two diskings that fall, resulted in limited spring survival ranging from 5% to 20% at the Fish and Wildlife Service Killcohook Refuge near Salem, N. J. The plants were growing on a fill deposited from dredgings of the Delaware River. After a third disking, cultivated crops were planted. In New Jersey mosquito-control programs it has been found that crushing and crimping by tractor wheels equipped with angle-iron cleats is more destructive to phragmites and other marsh plants than mowing.

At the Delta Duck Station in Manitoba, 3 years of summer mowing have been reported as effective in transforming phragmites beds into meadows on peaty soil which becomes dry in late summer. However, mowing on wet, nonpeaty soils elsewhere has given little or no control. Underwater cutting on small plots during the flowering season in Delaware and Maryland studies was effective, but the method has limited practicability.

BURNING

Burning appears to injure phragmites to only a minor extent except in localities where the plants are growing on peat. At the Delta Duck Station in Manitoba, late-summer burning not only

destroyed phragmites beds but also created useful sloughs by burning into the peat. Intensive burning continued for several years in the Imperial Valley of California and in gulf-coast marshes has proved unsuccessful in suppressing this weed. However, winter burning before spraying can be advantageous in making spraying operations easier.

FLOODING

Mature stands of phragmites cannot be controlled by raising the water level, but their seedlings can be drowned this way. Also a 12-inch depth of water during summer production of runners causes them to float on the surface instead of becoming anchored and thus prevents extension of an established stand.

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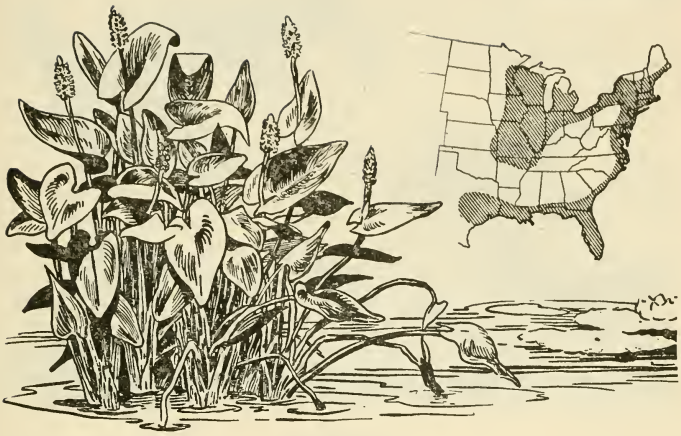
PICKERELWEED



BOTANICAL

Pickerelweed (*Pontederia*) in the United States has been classed either as one species, *P. cordata* with a variety *lanceolata*, or as two species. The lanceolate-leaf form is restricted mainly to the South. Pickerelweed has wide range in the East, but its main abundance and most extensive beds are in fresh or slightly brackish water along the Atlantic Coast and in the southern part of the Great Lakes area. The spikes of blue flowers are distinctive, and so are the somewhat heart-shaped leaves with rounded bases and no prominent veins. The plants are perennial from thick rootstocks.

IMPORTANCE

Seeds of pickerelweed are seldom eaten by ducks, and the plants are, in general, liabilities rather than assets in waterfowl habitat.

CONTROL

Limited experiments with pickerelweed in Delaware have indicated that the best control known at present is a double treatment: a foliage spraying of 2,4-D at the rate of 8 pounds acid equivalent per acre during the flowering period (late June in Delaware) followed 4 to 6 weeks later by a treatment with Ammate at 60 pounds active per acre.

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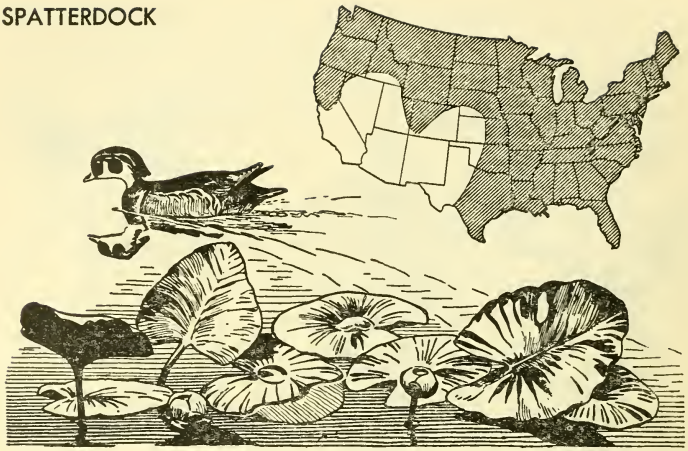
SPATTERDOCK



BOTANICAL

Some botanists recognize numerous species of *Nuphar* in the United States, whereas others treat the group as one species, *N. luteum*, with several varieties. Spatterdock, also known as cowlily, mulefoot (South), or yellow pondlily, is common in freshwater ponds, lakes, and slow streams in various parts of the country. The plants are able to grow in 5 feet or more of water, and their seedlings can develop in approximately that depth. Spread is by seeds and by rootstocks.

IMPORTANCE

Ringnecked ducks, wood ducks, and, to a lesser extent, other waterfowl feed on spatterdock seeds; in breeding areas, the plants can serve as useful brood cover, and they harbor insects upon which young ducks feed. The rootstocks are considered about a third-rate food for muskrats. In many locations it thrives under conditions of turbidity or fluctuating levels that preclude desirable vegetation, but in other places it is a serious competitor with more useful waterfowl plants.

CONTROL

Spatterdock is fairly difficult to destroy, and fully satisfactory methods have not yet been developed. The plant can be controlled by herbicides, or by cutting provided it is done at the right time.

The most vulnerable stage of growth has been determined to be the period of maximum blooming and early fruiting. Young seedlings are easily destroyed by dewatering, but killing mature rootstocks by this means is a slow process, especially if the stems are covered by silt.

HERBICIDES

A limited recent testing with ATA in New Jersey at 8 pounds acid equivalent per acre has given fairly encouraging results. Combination treatments with 2,4-D and Ammate have consistently yielded over 90% control in Tennessee and Delaware. A 2,4-D application at the rate of 6 pounds acid equivalent per acre during the time of heavy blooming and early fruiting was followed a month or 6 weeks later by spraying with Ammate at 80 pounds active per acre. Such combination treatments have been more effective than repeated sprayings with either 2,4-D or Ammate.

MOWING

Underwater cutting of spatterdock in about 4 feet of water at Reelfoot Lake showed, among other things, that a first cutting during heavy flowering and early fruiting followed by a cutting of regrowth about a month later gave 80% to 90% control. In shallower water, a third cutting about another month later was necessary for equivalent results. Cuttings made without regard to the vulnerable period are generally ineffective.

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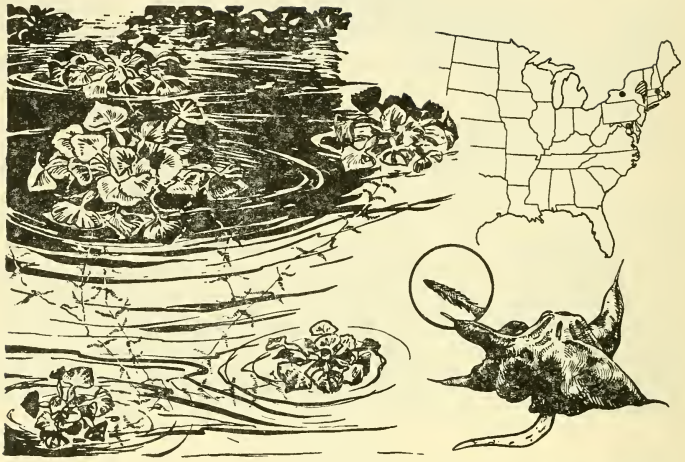
WATERCHESTNUT



BOTANICAL

Waterchestnut (*Trapa natans*), a native of Europe and western Asia, was found in a lake near Scotia, New York, about 1884. Since then it has spread to various points in New York State and has become established in Massachusetts, Vermont, and Maryland. Presumably it will continue to appear in new places. Other names for the plant are water caltrop, waternut, bullnut, and shingoda.

Waterchestnut grows in ponds, lakes, river estuaries, and slow-moving streams at depths varying from a few inches to about 15 feet. It thrives particularly at depths of 2 to 5 feet and favors muddy bottoms with high organic content. Though typically a freshwater plant, waterchestnut tolerates slightly brackish conditions such as those in parts of the tidal Potomac where the chlorine content during the average growing season ranges from about 1,700 to 3,500 parts per million of water.

Floating rosettes, commonly several of them produced on branches of the same plant, top the flexible stems. Leaf stalks are inflated, but not as conspicuously so as in waterhyacinth. In early summer, small white flowers develop in the rosettes, and these in turn produce large nutlike seeds armed with four sharp spines having minute retrorse barbs. Most of the seeds germinate in the following spring, but some may remain dormant and viable for years. The empty seed shells float to the surface and become a menace to bathing beaches.

Detached, well-developed rosettes are capable of taking root on muddy margins and maturing a crop of seeds. The plant is strictly an annual, and the comparatively small number of seeds produced, commonly a dozen or more, are its sole means of survival. Nevertheless, a small infestation located on the Potomac near Alexandria, Va., in 1923 extended itself 35 miles in 15 years —its beds blanketing much of the shallow water in this distance.

IMPORTANCE

Some use is made of the seeds as human food in Asia and Europe, but in this country the plant appears to be wholly a liability. The "waterchestnut" served in American versions of Chinese dishes is not *Trapa natans* but *Eleocharis dulcis*, an entirely different plant. Dense beds of waterchestnut can impede or preclude both commercial and recreational navigation, destroy usefulness of areas for bathing, fishing, and waterfowl hunting, and increase hazards from malarial or nuisance mosquitoes. It is not only a serious pest at present but also menaces waterways not yet invaded. Once in a river system, its eradication is costly. Control work on waterchestnut in the Potomac River required more than 20 years of extensive operations costing several hundred thousand dollars, and additional years of patrol and cleanup activity will be necessary before extermination is complete.

PRESENT EXTENT

NEW YORK STATE: Waterchestnut is estimated to cover about 2,500 acres in the Hudson and Mohawk Rivers. It appears rather hopelessly entrenched in these streams because danger to nearby crops limits safe and effective control. The plant has been largely or entirely eliminated in a number of small water areas near these two streams, but meanwhile it has invaded Lakes Keuka and Champlain.

MASSACHUSETTS: Beds in or near the Sudbury and Concord Rivers are reported to have been brought largely under control during the past decade, but it will be years before the weed is entirely eliminated here. An infestation in a pond on the Mount Holyoke College campus at South Hadley is a threat to the Connecticut River.

VERMONT: Waterchestnut was found on the Vermont side of Lake Champlain's southern end in 1950, presumably introduced by freight barges. Limited-scale control efforts are under way.

MARYLAND: Large beds of waterchestnut have recently (1954) been found in the Chesapeake Bay area, near the mouth of the Gunpowder River. Extensive cutting and spraying operations were conducted here in 1955, but only limited reduction was evident in 1956. Full control will probably not be obtained for a good many years, and meanwhile nearby areas valuable to waterfowl are endangered.

CONTROL

Since the plant is an annual, the main aim in control operations is to prevent maturing of new crops of seeds. It is these which maintain and spread infestations. All feasible means of control should be used. For extensive, dense beds, herbicidal spraying is likely to be practical. Underwater mowers are valuable, both for extensive cutting of beds and to clear paths for spraying equipment. Hand pulling and disposal of plants on land is advisable where growths are sparse or beds are small.

Timing of operations appears important. Cutting and pulling should begin early in the season, about the time small rosettes have reached the surface and before flowering and seed-setting have commenced. The best time for spraying is about midsummer when many of the leaves are forced above the water by the pressure of rosettes on each other. These conditions favor direct contact with the herbicide. Spraying after seeds are developed is likely to be too late.

After infestations have been suppressed, regular patrolling must be maintained for an indefinite number of years to prevent reestablishment. The maximum longevity of waterchestnut seeds is not known, but it is evident they can survive under silt for at least 10 years.

HERBICIDES

Tests by the New York State Department of Conservation in 1950 showed that though treatments with 2,4-D at rates of 2 or 4 pounds of acid equivalent per acre can be fairly effective, better or more uniform results were obtained at 8 pounds per acre. Amine and ester formulations of 2,4-D were found nearly equivalent in effectiveness. New York State has limited its control operations largely to amine-salt formulations to avoid danger of damage to crops and has made applications at the rate of 8 pounds acid equivalent in about 50 gallons of water or #2 fuel oil per acre. The Massachusetts Department of Conservation has used a low-volatile ester of 2,4-D at about 4 pounds acid equivalent in

50 gallons of #2 fuel oil per acre. In a limited part of the Gunpowder River infestation, the Maryland Board of Natural Resources appears to have obtained good results in 1955 (under reportedly ideal spraying conditions) with amine salt at the rate of about 2 pounds acid equivalent per acre in 25 gallons of water containing a detergent. Recently, however, the poundage has been increased.

Follow-up control within the same season may be necessary. Spray is likely to be less effective on foliage which is largely under water as in sparse stands or when waves wash over the rosettes. Airboats have proved useful for travel over beds during spraying operations.

MOWING

Cutting stems about a foot below the water surface can be very helpful in suppressing waterchestnut infestations. Hockney underwater mowers or other types of equipment, including sickles, can be used for the purpose. Mowing should begin early in the season, about the time small rosettes appear at the surface. Cutting at this time is easier and may involve less regeneration. At least one follow-up mowing is likely to be necessary within the same season. Mowing after the rosettes have begun to set seeds is not likely to be worth while since some seeds may have already dropped to the bottom and others can mature on drifting rosettes. In small operations it may be possible to remove cut rosettes and destroy them, but in larger operations this is not practical.

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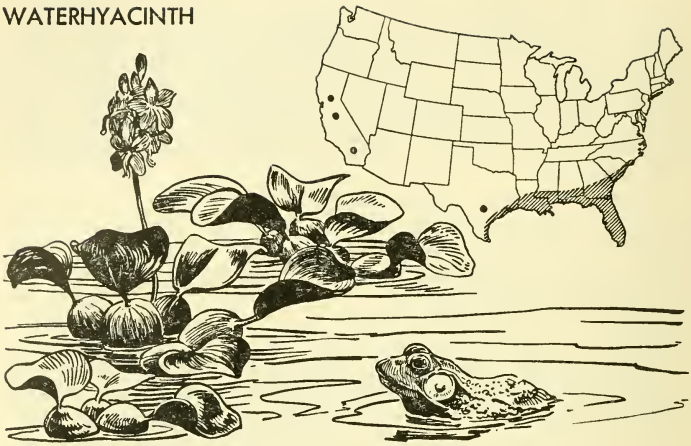
WATERHYACINTH



BOTANICAL

The tropical genus *Eichhornia* (also listed as *Piaropus*) includes three species in South America besides waterhyacinth, *E. crassipes*. The latter is a pest in North, Central, and South American countries, and in Australia, India, and Java, Africa, and other areas. In the United States it is confined by climate to the Southeastern Coastal Plain and a few California localities.

The plant thrives either free-floating, buoyed by bladderlike bases of the leaf stalks, or attached by roots to muddy margins. Rapid propagation occurs by offsets of small new plants. Three Louisiana plants are reported to have multiplied into 3,000 plants within 50 days by this means. Waterhyacinth also produces viable seeds, but propagation by seedlings appears to be negligible except on floating mats. The plant is also called hyacinth, lily, water orchid, and river raft.

IMPORTANCE

Waterhyacinth's beautiful flowers and curious form make it a popular aquarium specimen, but in other respects it is a weed. Its hindrance of navigation is so great that nearly 15 million dollars have been spent in efforts to control the pest during the past 40 years. In addition, waterhyacinth causes much harm by destroying usefulness of fish and wildlife habitat, hinders drainage, and increases malaria hazard. A 1947 report (Lynch and others) on the harmfulness of waterhyacinth and alligatorweed

states that "The wildlife crop these weeds destroy each year in Louisiana is valued at $14,727,000." It has been estimated that the total annual loss to Louisiana agriculture, fish and wildlife, navigation, drainage, and public health amounts to nearly 38 million dollars. Because of this economic drain, efforts are being made to reduce or eliminate waterhyacinth on thousands of acres of its present range.

CONTROL

Herbicidal treatment has proved so effective on waterhyacinth that mechanical methods employed formerly have been largely abandoned. The plant can be killed rather readily by light or moderate dosages of 2,4-D formulations except where floating mats are so dense that herbicide spray does not penetrate into lower layers.

Recommendations resulting from experiments conducted cooperatively in Louisiana, 1948–50, by the Boyce Thompson Institute, the Corps of Engineers, and Tulane University, included the following: Use of the alkanol amine salt of 2,4-D (for combined economy and low hazard to crops) at 8 pounds of acid equivalent per acre; spray concentration of 1.2% and 80 gallons of solution per acre in low-pressure spraying; in high-pressure treatment from a helicopter, 2 gallons per acre of the 8-pound acid equivalent formulation direct from the drum. Most effective killing and sinking of treated plants was found to occur in the period of relatively slow growth, from August to March.

Current practice in waterhyacinth control deviates considerably from the above recommendations. The amount of acid equivalent actually applied per acre in current control programs is as low as 1 or 2 pounds, the operators believing that these amounts are effective and adequate. The Research Committee of the Southern Weed Conference has recommended (1957) use of "1 to 4 pounds of 2,4-D acid equivalent in 2 to 150 gallons of water" for waterhyacinth control.

In recent years, the Florida Game and Fresh Water Fish Commission cleared more than 20,000 acres of waterhyacinth infestation on lakes and ponds in the State. This was done on a cooperative basis in which the landowners paid costs of chemicals, amounting to about $3 per acre, and the Commission footed the rest of the bill which was about $5. Aerial applications were made with a ½-gallon per acre of a 3.34 pounds acid equivalent ester formulation of 2,4-D, and treatments from boats (mainly airboats) involved ¾ gallon per acre of a 4 pounds acid equivalent

amine of 2,4-D in water. Since 1948, the Louisiana Wildlife and Fisheries Commission has conducted extensive control programs on waterhyacinth, and at present such activities have covered nearly half of the infested sections of the State. Efficiency in operations has been increased substantially recently by using lighter, lower-pressure spraying equipment and larger, more powerful barges. In a 1955 report on waterhyacinth investigations, the Florida Everglades Experiment Station in cooperation with the U. S. Agricultural Research Service and the Central and Southern Florida Flood Control District has advocated the use of 1 pound acid equivalent of 2,4-D amine per acre. The report indicates general expectancy that a 90% to 95% kill will result from the initial treatment.

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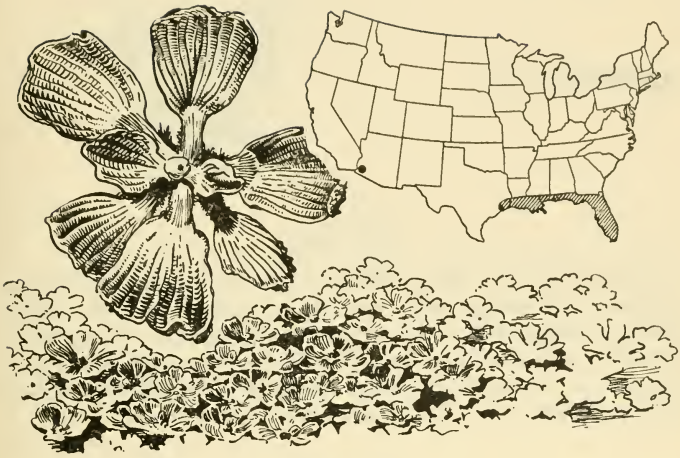
WATERLETTUCE



BOTANICAL

Waterlettuce (*Pistia stratiotes*) is a floating, semitropical plant limited to the Gulf region. Generally, it is much less abundant and important than its frequent associate, waterhyacinth. However, there is growing need for information on how to control waterlettuce since it is less susceptible to 2,4-D than waterhyacinth and its beds tend to spread in places where waterhyacinth has been killed. Water solutions of 2,4-D, such as are used in waterhyacinth control, are not effective on the velvet-surfaced leaves of waterlettuce. Consequently, oil carrier is required.

WATERLILIES

BOTANICAL

The two closely related species of white-flowered waterlilies, *Nymphaea odorata* and *tuberosa*, occur commonly and often abundantly in ponds and lakes of the Eastern States. Three other species have less importance as weeds because their distribution is limited. Banana waterlily, *N. mexicana*, is a valuable duck food locally along the Gulf and South Atlantic Coasts.

IMPORTANCE

Waterlilies, whether growing wild or planted in ponds or formal pools, are attractive to the eye, and their seeds have some usefulness as food for ducks. As long as their beds remain sparse they are not likely to be objectionable, but frequently waterlilies become so dense as to shade out submerged duck-food plants and interfere with fishing and boating.

CONTROL

At present, no method of control has proved uniformly effective on waterlilies in different places. Results with herbicides, including various formulations of 2,4-D, or with mowing have generally required repeated operations in two or more years. Excellent small-plot kills have been obtained with 2,4-D isopropyl ester at the rate of 2 pounds acid equivalent per acre on the Lacassine Refuge in Louisiana. The treatments were made in May on mixed growths of waterlilies and watershield (*Brasenia schreberi*) with the result that nearly pure stands of watershield dominated the plots.

Experiments with new herbicides are under way at several stations but at this time no conclusive results are available.

WATERPRIMROSES

BOTANICAL

The Southeast, the region in which waterprimroses are frequently nuisances in waterfowl habitat, has nine species of this genus (*Jussiaea*). Some of the nine are too limited in distribution or too sparse to be serious weeds. Two of the most abundant and troublesome ones are *J. diffusa* and *J. grandiflora*. Though some species grow erect in moist soils, others root on muddy margins of ponds or ditches and produce dense beds over water surfaces.

IMPORTANCE

Waterprimroses often do harm by competing with desirable plants; their seeds have limited local value as duck food.

CONTROL

The most vulnerable period for waterprimroses is during maximum flowering. *J. diffusa* can be controlled fairly easily by various 2,4-D formulations when applied at the rate of 4 pounds acid equivalent to 100 gallons of water, sometimes by a single treatment if the beds are not too dense. *J. grandiflora* is somewhat more resistant and generally requires several treatments with 2,4-D. In Maryland, good results were obtained from spraying with 2,4-D ester at 8 pounds acid equivalent in 100 gallons of oil, applied during the vulnerable stage. Water-carried sprays required wetting agents, and results were not as good as with oil.

WOODY WEEDS

In many localities, dense growths of trees or shrubs hinder production of desirable marsh vegetation. Woody weeds are problems in seasonally flooded swamps of the Southeast and various other regions, in bogs of northern States, and in thousands of acres of Southwestern lowlands that are covered by jungles of saltcedar, willows, and poplars.

Control of woody growths in swamps can be based on chemical or mechanical means, on water-level adjustments, or on combinations of these methods. Chemicals most practical for the purpose are 2,4-D, 2,4,5-T, "brush killer" mixtures of the two, Ammate, and under certain conditions, urea compounds. Herbicidal treatments include foliage spraying, basal spraying on the lowest foot or two of tree trunks, notch treatment consisting of placement of the chemical in notches of tree trunks, spraying or painting of stumps with herbicides, and ground injections to poison roots. Ground sterilants and basal treatments are of limited importance where flooding causes dispersion of the chemical.

Mechanical control by means of heavy disks, brush cutters, or similar equipment can be effective in sites suitable for such operations. One of the most effective ways of controlling woody growths is by cutting, followed with flooding of stumps for one growing season. Very few woody weeds can survive this treatment.

An important limiting factor in the control of woody weeds, particularly when applying herbicides to foliage, is insufficiency of knowledge of the stage of growth when control can be applied most effectively. For many species of woody plants, this vulnerable period can be defined in general terms as occurring in late summer or early fall during maximum foliage and before the leaves begin to deteriorate. The best dates for making applications on a particular species in a given locality must be ascertained for maximum efficiency. Applications made during other than the most vulnerable period are likely to necessitate extra treatments and costs.

Because of their importance in waterfowl habitat management, alders, buttonbush, saltcedar, and willows are discussed separately on the following pages. Additional trees and shrubs, mainly of lesser importance, are covered briefly under the heading Other Woody Weeds. Information on methods and materials for controlling various woody plants can be obtained from the references below.

REFERENCES

1955. Brush Control on Forest Lands. Walter G. Dahms and George A. James. USDA Pac. NW. For. and Range Exp. Sta. Res. Paper 13.

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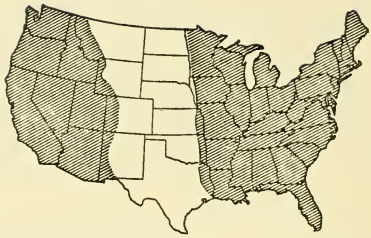
ALDERS



BOTANICAL

Of nine alder (*Alnus*) species native to the United States, three commonly produce thickets in bogs or swamps or occur as fringes on the margins of ponds. These are *rugosa* (formerly *incana*) and *serrulata* (formerly *rugosa*) in the East, and *tenuifolia* in the West. Though alders occur as far south as Florida, their principal abundance is in north temperate parts of the country.

IMPORTANCE

The value of alders for wildlife cover is limited, and their detriment to waterfowl habitat is considerable, particularly in impounded and dewatered units.

CONTROL

Tests by various organizations in different parts of the country have shown that alders can be controlled fairly satisfactorily by 2,4,5-T, 2,4-D, or Ammate, though commonly two or more treatments are necessary for eradication. Basal spraying (thorough wetting of lowest 2 feet of trunks) was found effective on *A. rugosa* at the Dunbar Forest Experiment Station, Mich. (Day, 1952). A solution containing 40 pounds of 2,4,5-T ester to 100 gallons of diesel oil gave 90% to 100% kill and 80 pounds of 2,4,5-T to 100 gallons of oil resulted in practically 100% control in either summer or winter. A commercial mixture of 2,4-D and 2,4,5-T gave nearly as good results, but 2,4-D alone was not as effective unless used at a 20% strength.

At the Patuxent Refuge a recent series of treatments involving complete spraying of alder foliage with 1% 2,4,5-T or 2% silvex in mid-August yielded effective control. Basal spraying of the Pacific Coast tree alder (*A. rubra*) with 32 pounds of 2,4,5-T in 100 gallons of diesel oil gave a 96% kill (Ruth and Bernsten, 1956).

REFERENCES

1956. Chemical Basal Treatment to Control Red Alder. Robert H. Ruth and Carl M. Bernsten. USDA Pac. NW For. and Range Exp. Sta. Res. Note 128.

1952. Controlling Alder With Basal Stem Sprays. Maurice W. Day. Mich. State Agr. Exp. Sta. Quart. Bul. 34 (4).

BUTTONBUSH

BOTANICAL

Our one native species of buttonbush, *Cephalanthus occidentalis*, is widely distributed in swamps and other wet places. It is common throughout the East and is particularly plentiful in the Lower Mississippi region; in the Southwest and California it occurs only locally. The shrub tolerates fluctuating water levels, shade, and acidity, and frequently develops dense, extensive thickets. Other names are buttonwillow, buttonwood, and elbowbush.

IMPORTANCE

In many places, buttonbush does not deserve classification as a weed. Frequently it is not abundant enough to be a serious competitor with useful plants, and in some places the duck food (seeds) and cover provided justify its presence. In many other places, however, habitat can be improved for waterfowl by reducing or eliminating buttonbush thickets.

CONTROL

Mechanical eradication of buttonbush has been successful in colder parts of its range. The water level is drawn down as low as possible before freeze-up, and when the ice becomes safe the plants are cut with a rotary brush mower. Later, the water level is restored to keep the cut stems inundated during the growing season. The effectiveness of this technique depends on sufficient depth and duration of submergence.

The plant is rather difficult to kill with herbicides. This is particularly true when it is on exposed margins or other unflooded sites. Effective control resulted from the use of Ammate at 60 pounds to 100 gallons of water in the Kentucky Woodlands Refuge in flooded habitat (Steenis, 1950).

2,4,5-T is more effective on buttonbush than 2,4-D. Recent tests on buttonbush control at the Patuxent Refuge in mid-August have shown promising preliminary indications from treatments with combinations of 50 pounds TCA and 4 pounds 2,4,5-T.

REFERENCE

1950. Studies on the Use of Herbicides for Improving Waterfowl Habitat in Western Kentucky and Tennessee. J. H. Steenis. Jour. Wild. Mgt., 14 (2).

SALTCEDAR

BOTANICAL

Several species of tamarisks (*Tamarix*), of about 75 that are native to the Old World, have been cultivated as ornamentals in this country. Of these, saltcedar (*T. pentandra*), has become a serious pest in the West during the past half-century. Normally it is a shrub or small tree, but under favorable conditions it grows 25 feet or higher. On reservoir margins, river deltas, and other places that are moist part of the year, saltcedar forms heavy thickets, sometimes pure stands extending for miles. More frequently it is mixed with cottonwoods and willows. When their tops are killed or cut, saltcedar trees regenerate readily by sprouts. They also reproduce effectively by seed, frequently thousands of seedlings appearing in one season.

IMPORTANCE

Saltcedar has become the No. 1 wetland weed of the Southwest. The tree is not only a detriment to waterfowl habitat on thousands of acres of overflow and river-bottom land, but it also causes serious economic loss (through transpiration) of great quantities of water needed for irrigation, and harms grazing interests by competing with grasses or other useful vegetation. In addition, dense stands of saltcedar along some stream courses have caused flood damage to adjoining land by impeding flow at high-water stages. Bees get nectar from the flowers, cattle use the thickets for shelter, and in some river basins the plant is considered desirable for erosion control, but on the whole it is much more of a liability than an asset.

CONTROL

While saltcedar has been controlled quite effectively along irrigation and drainage canals by high-volume spray applications of 2,4-D, investigations by several agencies since 1951 have thus far found no satisfactory, effective method of eliminating it from river deltas, reservoir margins, flood plains, and other areas where extensive thickets exist. Instead, tests have made it clear that the plant is difficult and costly to control in these situations by either chemical or mechanical means. Results with 2,4-D or 2,4,5-T sprays or with combinations of the two have been inconsistent. Generally, repeated treatments have been necessary, and ordinarily fair to good results have been obtained only at dosages of 2.5 or more pounds per acre. Basal spraying has been moderately successful.

Hundreds of acres of Federal refuges have been cleared of the pest in the past few years by use of heavy equipment (bulldozer, bush-and-bog disk, and rotary tiller) and by follow-up maintenance. In general, sod or cultivated crops must be sown after clearance, and in addition saltcedar seedlings need to be sprayed periodically to prevent reestablishment of thickets. Mechanical control followed by spraying of regrowth is generally regarded as the best means of combating saltcedar, as indicated in point 11 of the following summary from a report (Arle, 1957) by H. Fred Arle of the Bureau of Reclamation:

1. Saltcedar is more difficult to kill on flood plain situations than along irrigation channels and streams.

2. Single spray operations have never given satisfactory total plant kill of adult saltcedar and only rarely have two repeated treatments eliminated 80% or more of the plants.

3. Periodic spraying of infested areas with 2,4-D and 2,4,5-T will defoliate saltcedar and in this manner reduce transpiration losses.

4. Applications of 2,4-D and related materials appear more effective on young regrowth following mechanical destruction than on adult saltcedars.

5. Application rates of less than 2.0 pounds per acre have generally given poor results.

6. Low volatile esters of 2,4-D or combinations of 2,4-D and 2,4,5-T have been consistently more effective than amine or sodium salts of 2,4-D.

7. Dormant applications of 2,4-D and 2,4,5-T esters have shown promise in the control of saltcedar.

8. Mechanical means, although expensive, are useful in the eradication of saltcedar, especially in areas near cotton or other crops susceptible to 2,4-D.

9. Mechanical control must be exercised at least yearly to eliminate regrowth from root sprouts and seedlings.

10. Saltcedar is more difficult to kill with 2,4-D and related materials than most willows, cottonwoods and other woody phreatophytes.

11. Mechanical clearing followed by spraying of young regrowth with 2,4-D or a mixture of 2,4-D and 2,4,5-T at 2.5 pounds or more per acre repeated as necessary once or twice a year appears to be the most effective and practical method now known for controlling saltcedar.

REFERENCES

1957. A summary of results of experimental and field trials pertaining to the control of saltcedar (*Tamarix gallica*). H. Fred Arle. Proc. Amer. Geophysical Union.

1957. History of the Introduction of Saltcedar into the United States. Curtis W. Bowser. Proc. Amer. Geophysical Union.

1957. The Phreatrophyte Problem. T. W. Robinson. Proc. Amer. Geophysical Union.

1951. Report to Saltcedar Interagency Council. Interagency Task Force, Albuquerque, N. Mex.

WILLOWS

BOTANICAL

The numerous species of willows (*Salix*) that invade waterfowl habitat in various parts of the continent are particularly troublesome where fluctuating water levels favor establishment of seedlings. Most willows grow rapidly and are capable of propagation by seeds, by shoots from roots, or by broken-off twigs or branches rooting in the mud.

IMPORTANCE

Willows have minor value to wildlife and to man in various ways. In the North, elk, moose, deer, beaver, and several species

of grouse, feed extensively on the bark, twigs, and buds. In regions of the West where cover is scarce, willows sometimes provide useful protective or nesting cover for game birds. Locally, willows have been used for controlling soil erosion on stream banks. Their light, pliable wood has some value for cooperage and other purposes. On the other hand, besides crowding out duck-food plants in waterfowl areas and necessitating the spraying of several hundred acres of willows on Federal refuges each year, willows cause serious water losses on margins of western reservoirs and irrigation canals.

CONTROL

Herbicides, particularly 2,4-D formulations, are the most practical means of destroying willows. On black willow (*S. nigra*), control ranging from 95% to 100% may result from a late-summer foliage spraying with dosages of 4 pounds 2,4-D to 100 gallons of water. Effectiveness of treatment varies with the species, and in time it may be possible to give specific recommendations for each of the more important kinds of willows. Glossy-leaved species are likely to require a "sticker" in the spray. Injection treatments (into cuts on trunks) and basal spraying are generally not recommended for willows except for larger species such as the black willow or in instances where specimens are too tall or too few to justify foliage spraying.

Control recommendations based on studies by various organizations in western States have been summarized in the 13th Western Weed Conference Research Progress Report (Butler, 1952). Some of the principal findings reported are as follows:

2,4-D is more effective on willows than the more expensive 2,4,5-T.

Both the amines and the esters of 2,4-D are satisfactory at comparatively low rates.

Aerial spraying using large droplets has been effective in applications as low as 3 pounds of acid equivalent in one gallon of oil per acre.

Early summer applications seem best for foliage sprays.

Old willows are likely to require treatment for 2 or 3 successive years. The dead tops can be felled and burned more readily during or following the second winter after the original treatment. Such removal is desirable for efficient treatment of sprouts and for final eradication.

For land spraying of foliage, 100 to 400 gallons of solution per acre may be required to wet foliage effectively. In contrast to this, airplane spraying of willows in the Strawberry Valley in Utah was effective with 3 pounds of acid equivalent in one gallon of solution per acre.

A helicopter proved very satisfactory for spraying willows along canals near Malta, Mont.

REFERENCE

1952. Undesirable Woody Plants on Irrigation Systems and Irrigation Lands. C. C. Butler. Res. Prog. Report, 13th Western Weed Conf.

OTHER WOODY WEEDS

Plants discussed under this heading are given only limited space because of their lesser importance and because, in some instances, little is known about their control.

Along permanently or seasonally flooded areas in western Kentucky, small or medium-sized sprout growths of red maple (*Acer rubrum*), green ash (*Fraxinus lanceolata*), and sweet gum (*Liquidambar styraciflua*) have been controlled satisfactorily with various formulations of 2,4-D salts and esters at the rate of 4 pounds per 100 gallons of water applied in late summer (Steenis, 1950). Equivalent results were obtained with Ammate at 75 pounds per 100 gallons. However, in better-drained sites, such treatment produced only partial control of these species. Trumpetvine or cowitch (*Tecoma radicans*), a woody creeper that is a problem plant on islands and seasonally flooded margins of TVA impoundments and other Southeastern reservoirs was controlled readily with the same dosage of 2,4-D or with Ammate when treatment was made in early fall (August 15 into September).

Recent tests in Maryland have shown that both of the common saltmarsh shrubs, groundselbush (*Baccharis halimifolia*) and high-tide-bush (*Iva frutescens*), can be controlled by 2,4-D formulations at about 4 pounds per 100 gallons if treated in late summer or early fall. Also, these plants and bayberry (*Myrica*) were killed readily in coastal North Carolina by monuron pellets scattered sparsely around the bushes.

In Delaware, the semiwoody weed decodon (*Decodon verticillatus*) has been controlled readily by 4 pounds of 2,4-D per 100 gallons. The treatment proved effective during different parts of the growing season, from June into August.

Recent studies on leatherleaf (*Chamaedaphne calyculata*) by the State of Wisconsin have indicated that this common shrub of northern bogs, can be controlled up to about 90% by a single summer treatment of 2,4-D or 2,4,5-T at 4 pounds acid equivalent per 100 gallons. Higher poundages of the herbicides yielded higher percentages of kill.

REFERENCE

1950. Studies on the Use of Herbicides for Improving Waterfowl Habitat in Western Kentucky and Tennessee. John H. Steenis. Jour. Wild. Mgt. 14 (2).

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